Water Resources Management Program at Los Alamos National Laboratory

Sustainable Use and Global Understanding

LAUR-01-5357

Why Worry about Water?

Global Freshwater Crisis

World Population Outstripping Available Water Supply

Available freshwater in lakes and streams only 0.00019%

2025 Freshwater Shortfall equals 2,000 m^2

Water Shortage Impacts

1.4 + billion people lack access to safe water supply (UN)

50% of people globally lack adequate sanitation

20% of world's freshwater fish species are endangered because of water-related causes

80% of disease in developing countries caused by contaminated water: 5-7 million people die annually, one child every eight seconds

U.S. Security Concerns

Transboundary water conflicts create security concerns for the United States

Water security flashpoints: Jordan River, Nile Basin, Mekong Basin, East Asia and South Africa

Water shortages threaten regional stability in China, India and Mexico

Water & Economic Security

Foreign disaster relief:

- **Floods and drought cost billions in damage and loss of life**

Decreased agricultural production:

- **Water shortages**
- **Water Contamination**

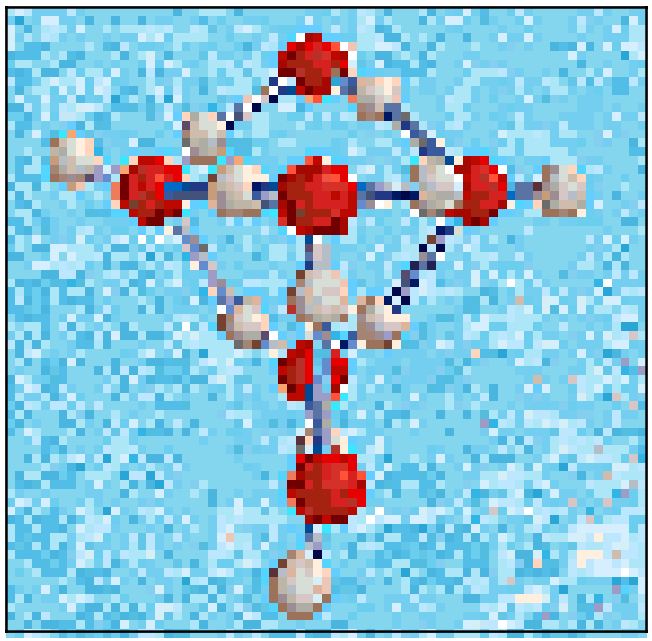
Health related costs:water-born disease

Increasing energy costs

Major Scientific Challenges

Impact of the Global climate on hydrologic cycle

Interaction of the carbon cycle with the hydrologic cycle



Local and regional solutions to contamination

Consequences of energy utilization

Integration of models across multiple scales

Climate-change models with sufficient regional resolution to predict water resource availability

Why Los Alamos?

- National Security Mission Includes Environment
- Unique Complex Systems Integration and Problem Solving Abilities
  - High performance computing
  - Modeling and simulation systems
- Shared Scientific and Technical Contributions

Los Alamos NATIONAL LABORATORY

NM semi-arid region is both case study and test bed for new science and technology approaches

Water Resources

Los Alamos
NATIONAL LABORATORY

- **Laboratory operations require monitoring of legacy contaminants**

- **Water use and conservation are important elements of operational activities since water availability can limit future program development**

- **43 square mile, instrumented test bed for hydrological measurement and research**

Hydrogeologic Work Plan

Why: State concerns over contamination flow and transport

Goal: Characterization of Pajarito Plateau

Science: Comprehensive data management

- **3-dimensional model of geologic structure**
- **Flow & transport modeling to test alternatives**

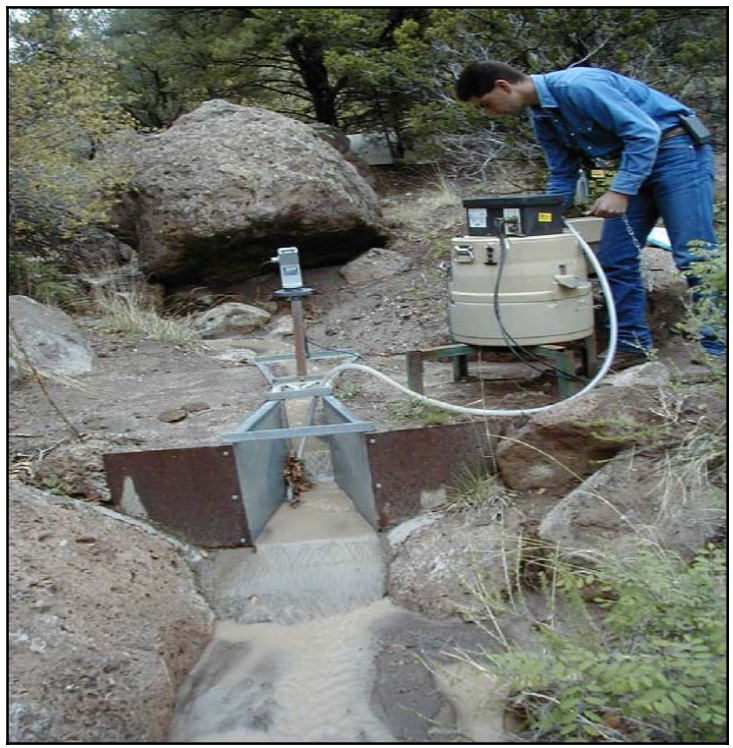
Result: Information for management of contamination transport

LANL Watershed Planning and NPDES Storm Water Monitoring

Goal: Collect critical information on storm water runoff

Science: Automated stream-monitoring stations in canyons:

- **Trigger collection of samples from runoff events**
- **Inform Lab that a sample is collected**
- **Provide discharge record for tributaries and canyons**



Result: Monitor compliance with State & Federal regulations

Water Resources Regulatory Compliance Programs at LANL

Goal: Assist U. S. EPA and NMED to develop water standards

Science: LANL collections, data and models

Result: Appropriate Federal and State Standards (i.e., arsenic, uranium, etc.)

Water Quality Research

Goal: Reclaim usable water supplies with treatment technologies

Science: Develop new separation materials & hybrid membranes

Result: LANL has developed award-winning (R&D 100) water treatment technologies in groundwater, drinking water, process water, and drainage water that impact DOE contaminated sites, industry and health

P2/Waste Minimization Project: Western Area Sanitary Water Reuse

Goal: Improve SWS operation and decrease Lab reliance on potable water for cooling

Science: Increase organic loading by diverting 200,000 GPD of influent from LAC

Result: Project will save 223 AFY

Water Conservation Project

Goal: Maximize efficiency of water used in cooling towers

Science: Eliminate silica

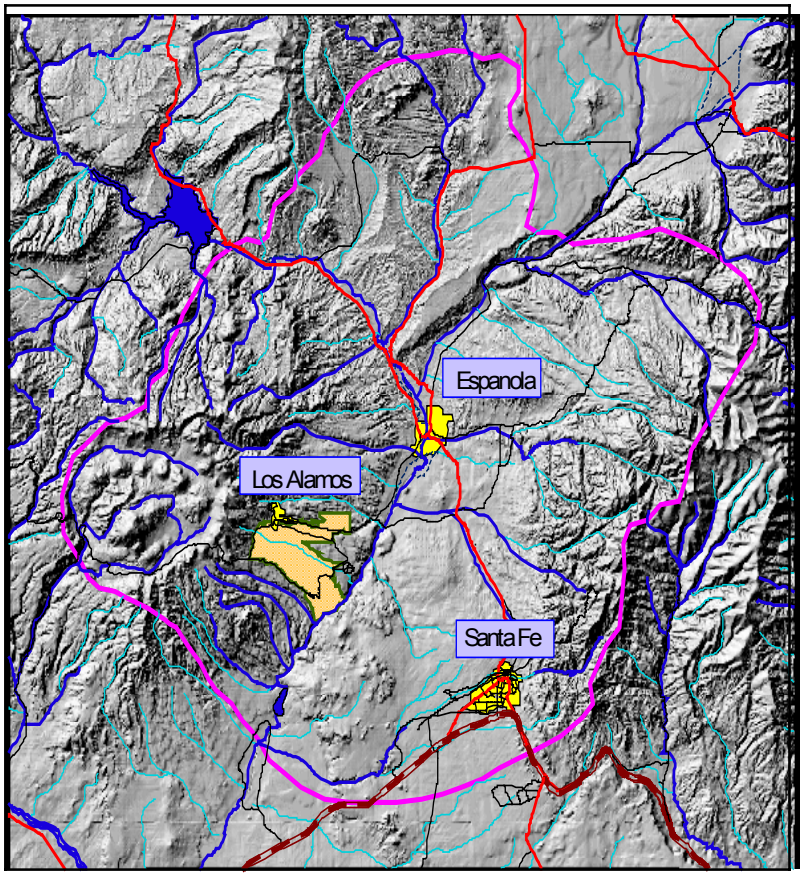
Result: Assure adequate water supply for future missions

Regional Water Programs

Los Alamos is:

- **A major user of regional water resources**
- **A partner in regional water agreements**
- **A neighbor in Northern New Mexico**
- **A source of technical support to local, state and regional planning activities**

Espanola Basin Aquifer Model



Goal: Predict future changes in groundwater quality & quantity

Science: LANL is developing:

- **3-D geologic model**
- **Flow & transport models of regional aquifer and Pajarito Plateau**

Result: Predictive models to support groundwater protection and regional water planning

National Science Foundation Science and Technology Center

Goal: Integration of field observations & coupled modeling

Science: Coupled numerical modeling

Result: Understand Rio Grande Basin hydrogeology & coupled physical/chemical water processes

Collaboration between: LANL, SAHRA, NMIMT

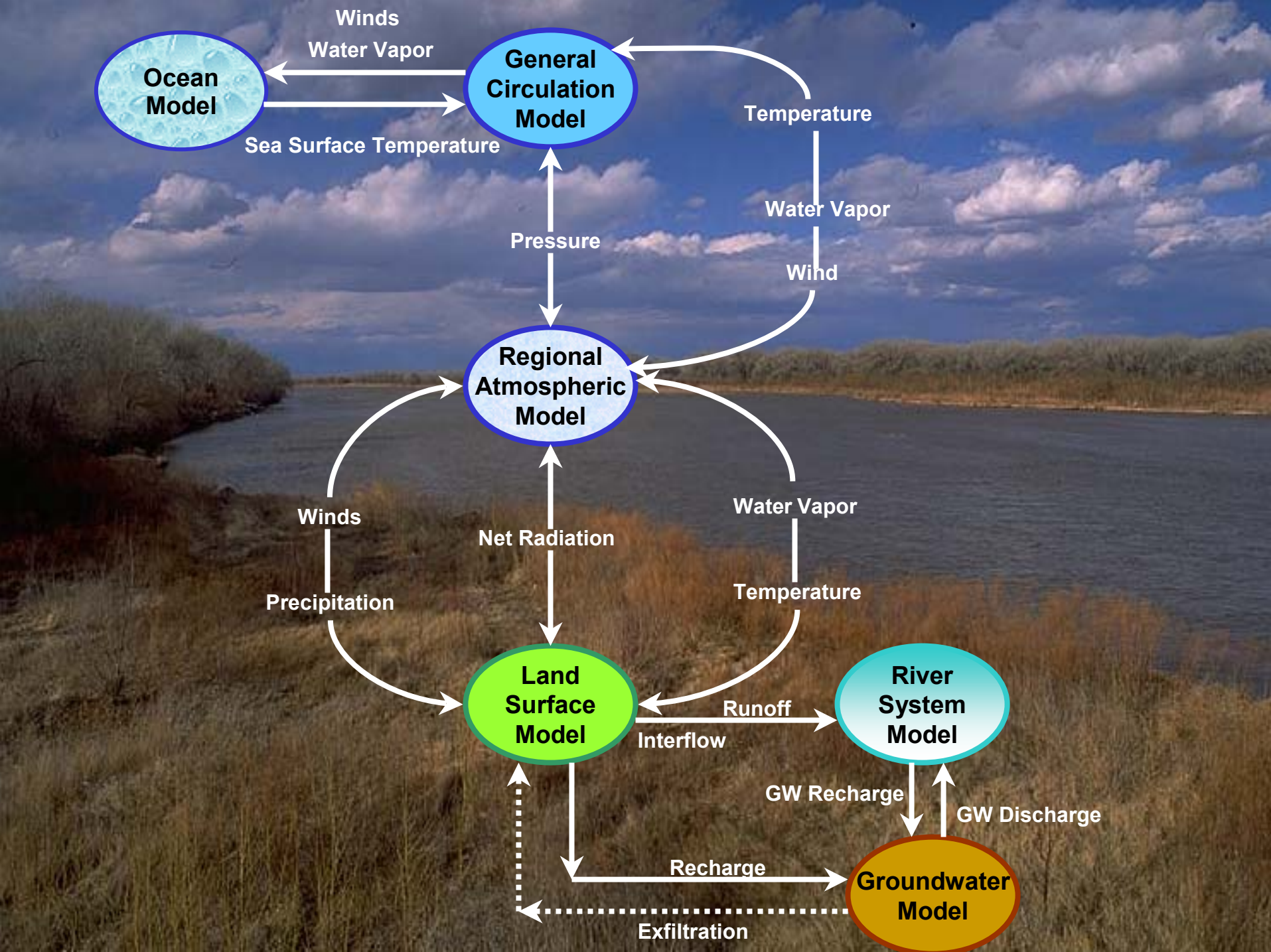
Rio Grande Integrated Water Cycle Model

Why: Regional Water Use is Vulnerable to Climate Change

Goal: Provide High Resolution Regional Water- Resource Predictions Within a Global Climate Context

Science: Integrate Surface Hydrology, Groundwater & Atmosphere in Rio Grande Water-Cycle Model

Result: More informed decision making & predictive capability


Winds
Water Vapor
Ocean Model
General Circulation Model
Sea Surface Temperature
Temperature
Water Vapor
Wind
Pressure
Regional Atmospheric Model
Winds
Precipitation
Net Radiation
Water Vapor
Temperature
Land Surface Model
Runoff
Interflow
River System Model
GW Recharge
GW Discharge
Recharge
Groundwater Model
Exfiltration

Jemez y Sangre Regional Water Plan

Goal: Interstate Stream Commission has mandated regional water planning to prevent out-of-state water transfers

Science: Supply/demand & populations projections

LANL has supplied an extensive database & significant staff resources

Result: 40-year plan for supply and demand equilibrium

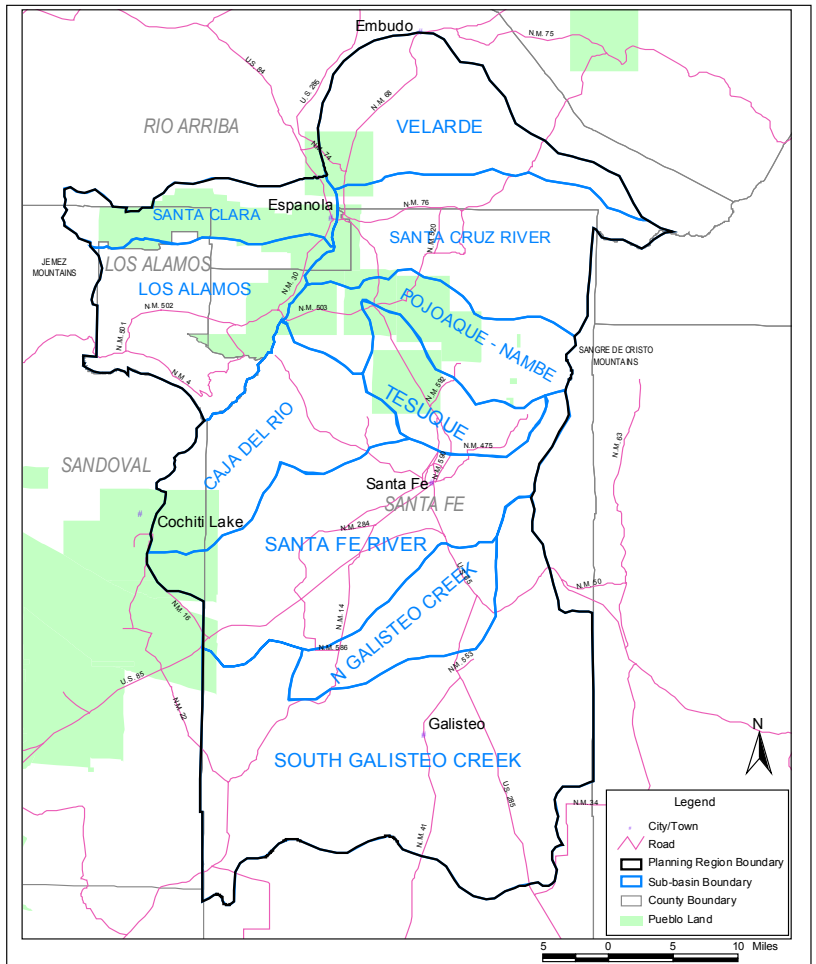


Figure 1-1 Jemez y Sangre Water Planning Region and Sub-basins

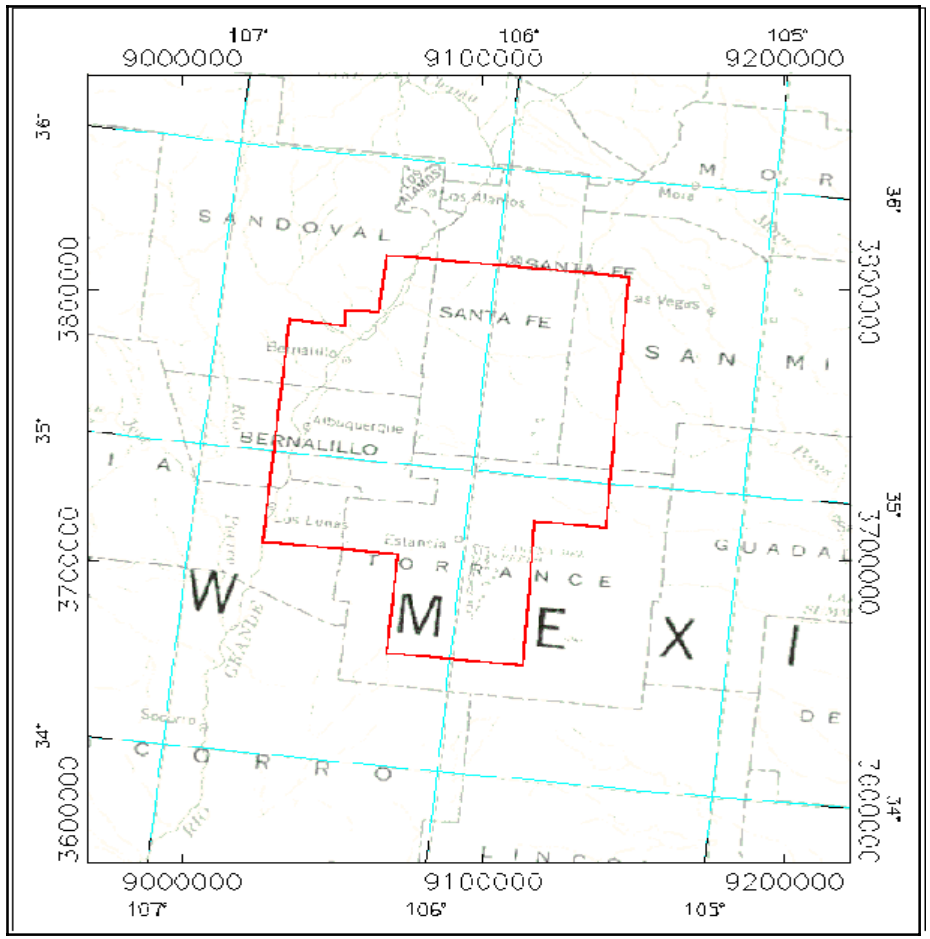
Duke Engineering & Services

Estancia Basin Water Planning Commission

Goal: Predict aquifer depletion and salt water intrusion in the Estancia Basin

Science: LANL's process-modeling capability and Sandia's decision-analysis capabilities

Result: Framework for decision making on 40-year plan for ISC



Governor's Blue Ribbon Task Force on Water

Goal: To recommend changes to water policy and water law

Science: Technical support from LANL

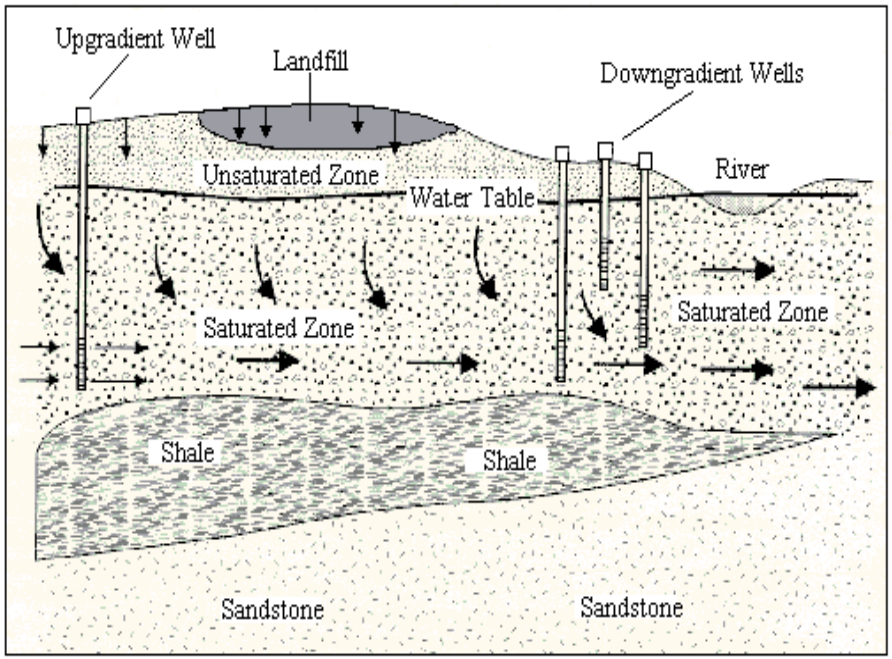
Result: Remove barriers to water administration

National Water Programs

- **Los Alamos is a major contributor of scientific and technical expertise on water resources measurement, modeling and simulation**
- **Work with DOE on fate and transport of contaminants in vadose zone and for repository citing verification**
- **Understanding of the hydrological cycle and the carbon cycle in global climate change and major target**
- **Key High Performance Computing capabilities**

DOE VADOSE ZONE ROADMAPPING

Goal: To understand the Vadose Zone & Accelerated Fluid Flow



Science: Physical and chemical process models; computational models; field experiments and instrumentation

Result: Information for resource management decisions

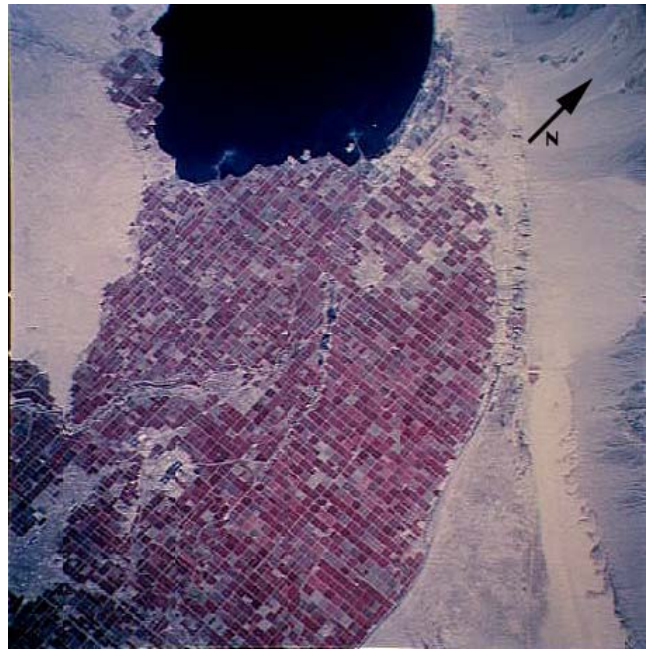
Collaboration between: DOE-Idaho, INEEL (lead), LANL, SNL, LLNL, SRL, Multiple Universities

Salton Sea Reclamation Studies

Goal: Restore Salton Sea for aquatic life and recreation

Science: Evaluation of

- **–Diked impoundment of lake**
- **–Pump-in pump-out**
- **–Desalination**



Top: Salton Sea,surrounded by agriculture. Left: Tilapia fish

Result: LANL testified on findings to US House of Representatives, Subcommittee on Water and Power

LANL's Role in DOE Atmospheric Radiation Measurement Program

DOE ARM site on the island of Manus in the equatorial Pacific

Goal: Refine global circulation models

Science: Measure cloud properties and relate these measurements to climate processes

Result: Better understanding of Global Warming

Office of Biological & Environmental Research for U.S. Global Climate Change Research Program

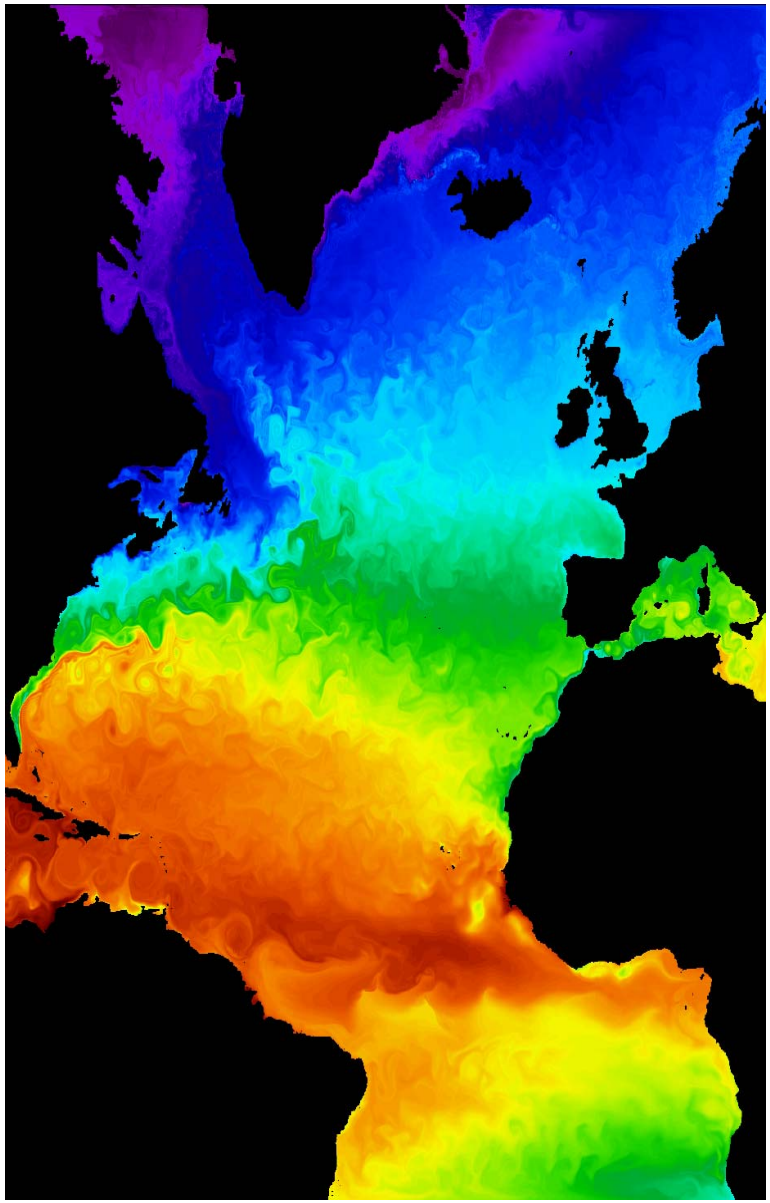
Draft Science Plan:

LANL co-chairs committee to develop scientific foundation

Goal: Predict seasonal to decadal variability of the regional water cycle

Science: Coupled modeling & development of three regional test beds

Result: Information for water resource management



Climate, Ocean, and Sea Ice Modeling (COSIM) project

Goal: Develop and validate ocean and sea ice models

Science: New techniques for modeling ocean circulation, e.g. El Nino/La Nina cycle simulation

Result: Fully coupled climate model

Los Alamos
NATIONAL LABORATORY

International Activities

- Los Alamos science, technology and organizational activities extend to global water resources issues
- Global crisis in freshwater availability requires innovative and integrated solutions
- Los Alamos expertise used by White House, State Department and other government agencies
- Water pollution prevention a major theme

US-China Water Resources Management Program

Goal: Long-term science and technology programs between China and US

Science: Water resource efficiency in arid climate

Result: Scientific alliance between China & US

LANL coordinates 11 US government organizations to accomplish this goal

Committee on International Science, Engineering & Technology

LANL leads White House Office of Science & Technology Water Working group

Goal: Anticipate S & T issues related to global water crisis

Result: Avoid global conflict

Los Alamos
NATIONAL LABORATORY

Science and Technology

- **Los Alamos science and technology working on underlying basis for water resources management decisions**
- **Global crisis in freshwater availability requires innovative and integrated solutions**
- **Conservation and Green Chemistry included**

Water Saving Technology

Goal: Eliminate water-based cleaning system in chip fabrication

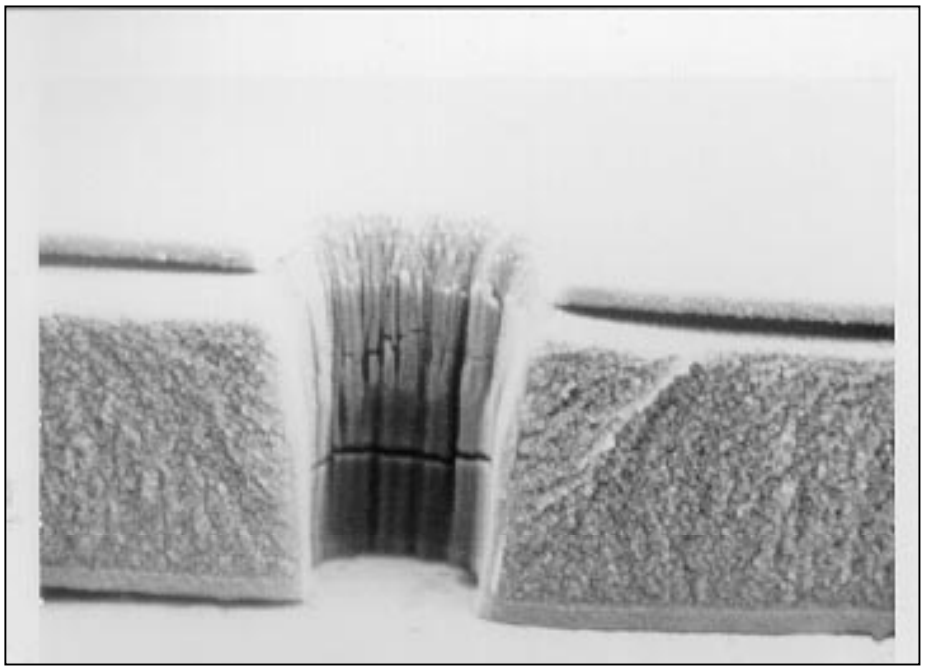
Science: Supercritical Resist Removal uses CO2 with propylene carbonate additive

Result: Water conservation & reduced operation costs

National Science Foundation Science & Technology Center Participants

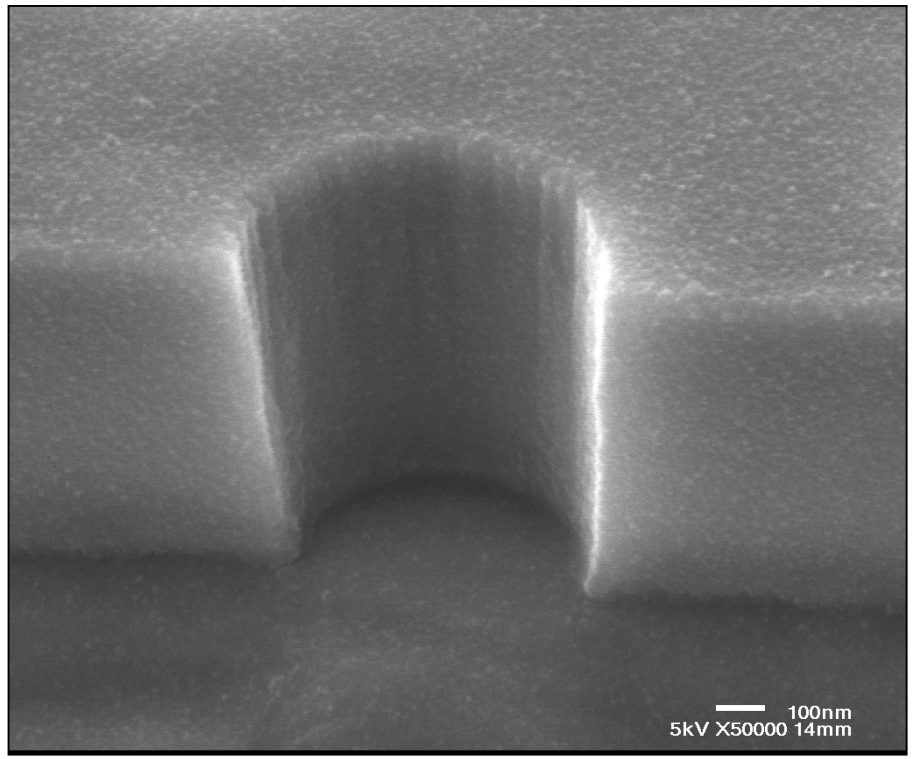
Diverse Capabilities Hold the Answers to Global Water Problems

Semiconductor Photoresist Removal



Semiconductor component showing sidewall polymer prior to cleaning

Semiconductor component
After SCORR cleaning



Plants with Improved Water Use Efficiency

Goal: Produce better plants with less water

Science: Identify and manipulate nutrient and carbon fixation mechanisms in plants

Result: Prototype plants successfully improve nitrogen use and water efficiency

Improved Water Conservation with Waste Materials

Goal: Increase plant productivity with reduced water

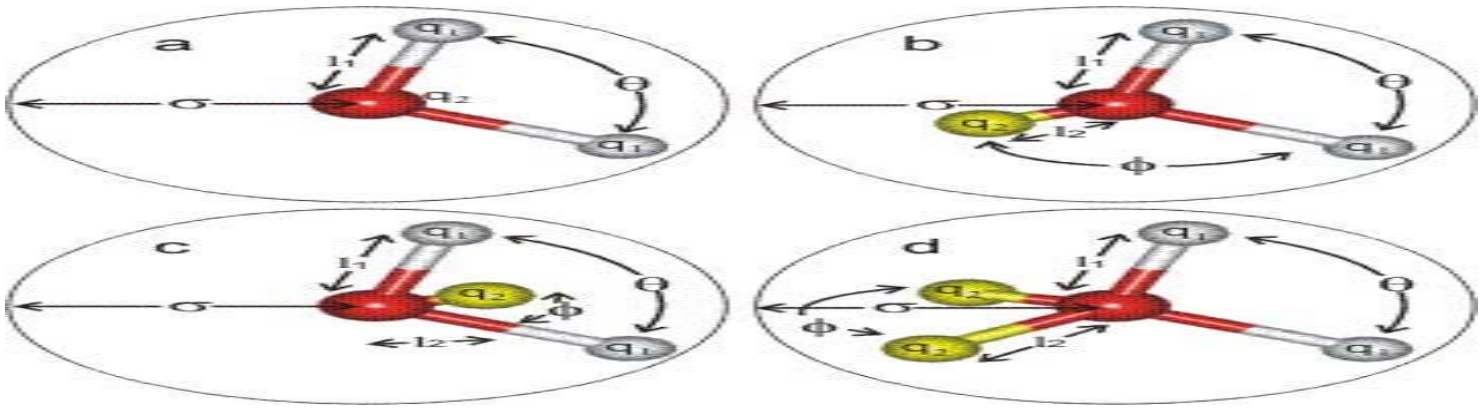
Science: Clay soils and coal mine spoil combinations are being tested for their ability to support plant growth in water limited growth regimes

Result: Combinations outperform productivity of plants in exclusively native soil or exclusively mine spoil

Greenhouse studies are a collaboration between the State of New Mexico and LANL.

Understanding Uncertainty in Water Resource Predictions

- **Goal: Predict a range of possibilities to different answers**
- **Science: Probablistic models**
- **Result: Understand the probability of achieving an outcome**



Effects of Plant Cover on Water Resources

Goal: To better understand how spatial variation in vegetation influences evapotranspiration

Science:Coupled modeling of hydrologic and chemical effects by automated field data collection

Result: Reduction in ET

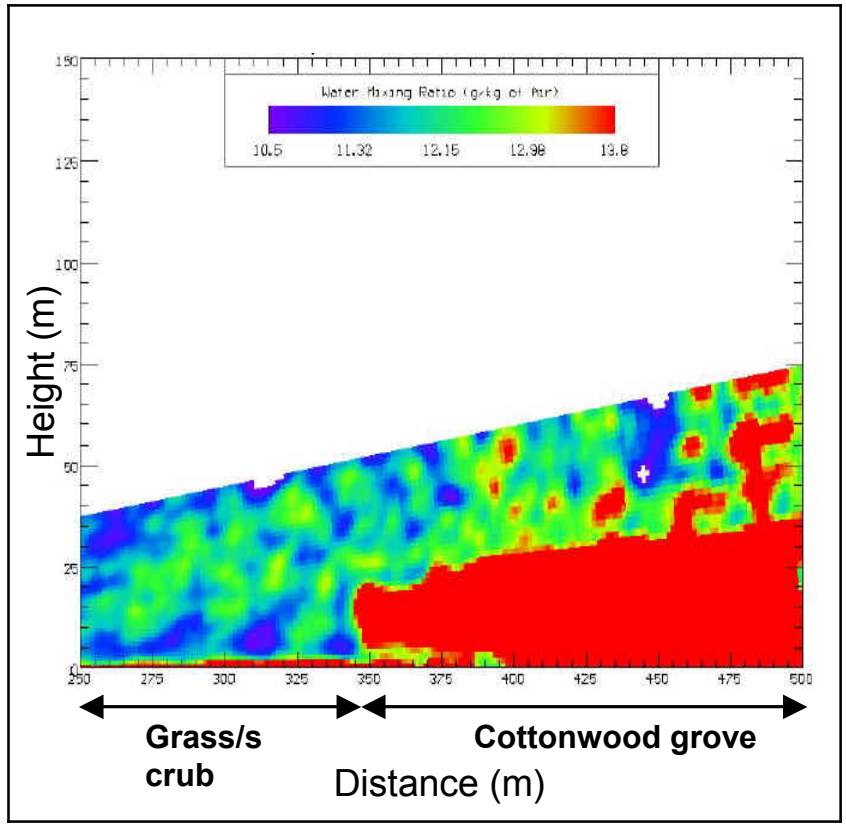
Collaboration with Southwestern Universities

Evapotranspiration Processes

Goal: To better understand the exchange of water vapor between the surface and the atmosphere

Science: Using LIDAR, rising and falling plumes and eddies of moisture can be seen and quantified.

Result: Identify water-saving improvements to ecosystem



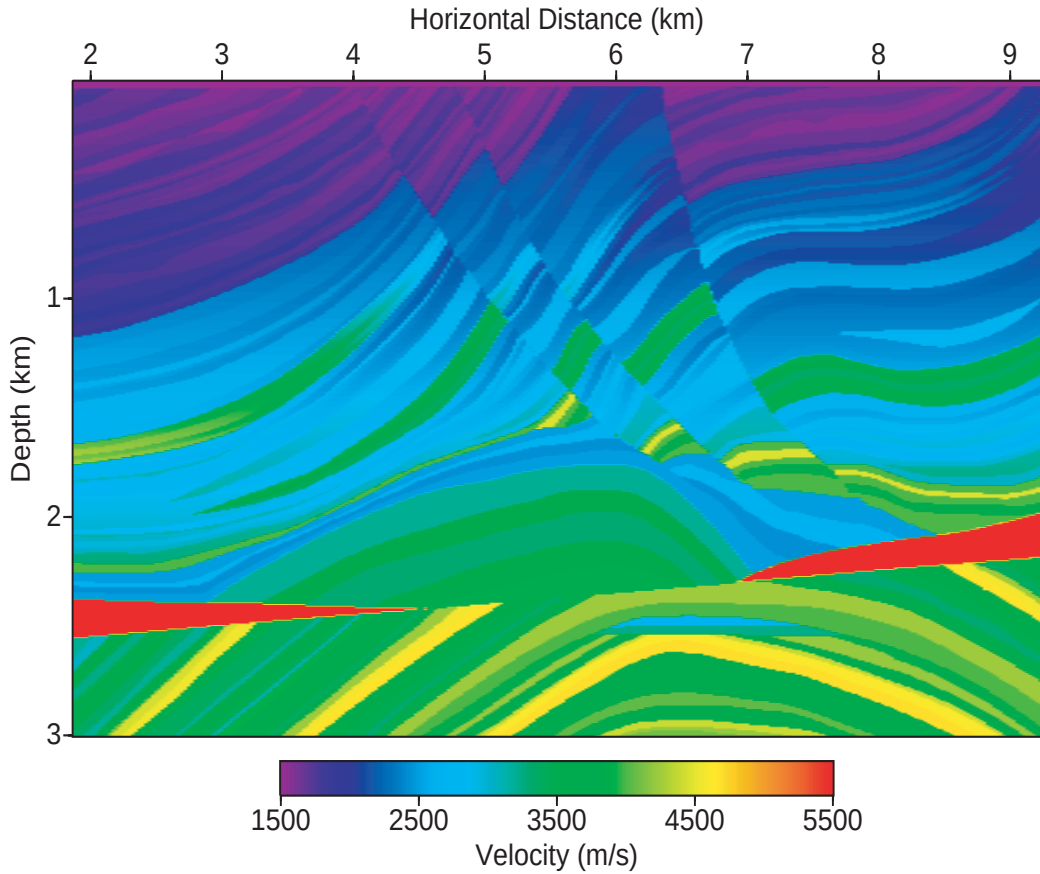
Moisture levels over canopies show which trees consume the most water. LANL Raman Lidar Scan, San Pedro River Bosque

Reservoir Characterization

Goal: Petroleum exploration using seismic data

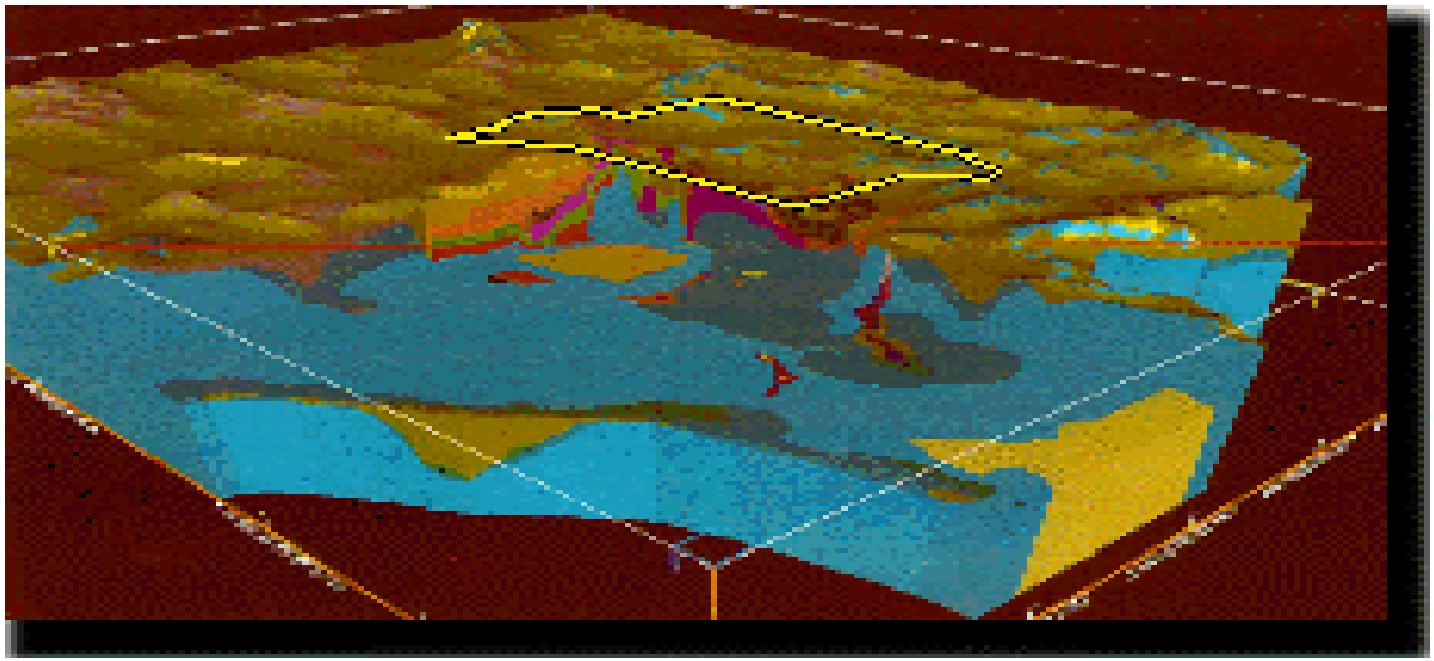
Science: Extended Local Rytov-Fourier Method, used by LANL scientists, lead to far superior images of the Earth's subsurface

Result: Applications for groundwater location and characterization.



Marmousi Model

Underground Test Area (UGTA)



Goal: To evaluate groundwater contamination from nuclear activity at Nevada Test Site

Science: Study radionuclide migration in groundwater

Result: Determine need for clean up of groundwater

Los Alamos
NATIONAL LABORATORY

Vision Statement

We serve the nation by applying the best science and technology to make the world a better and safer place

Mission: National Security

Accelerate focus on environmental solutions to make the world a healthier, safer and more prosperous place

LANL expertise in water chemistry, aqueous separations, hybrid membranes, coupled modeling and complex computing systems put us in a position to positively impact quality of life and world peace